

# Antiferromagnetic Resonance in Lanthanum Manganese Oxide

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Abstract No. Miha1309

Beamline(s): U12IR

**Introduction:**  $\text{LaMnO}_3$  is the parent compound of a series of doped perovskites exhibiting unusually large magnetoresistance<sup>1</sup>. In terms of an ionic limit, the electronic configuration of  $\text{Mn}^{3+}$  is  $t_{2g}^3 e_g^1$ , and the strong Hund's rule coupling causes the electron spins to form an  $S=2$  state. The single electron on the two-fold degenerate  $e_g$  orbital causes a collective Jahn Teller distortion, resulting in a lattice distortion of  $c/\sqrt{2} < a, b$  in the  $P_{bnm}$  structure. The distortion selects one of the  $\text{MnO}_2$  planes, where the Mn-O distances follow an alternating pattern of short and long bonds<sup>2,3</sup>. The hybridization of the  $e_g^1$  electron and the O orbitals results in a coupling between the Mn sites. In the presence of "antiferromagnetic" orbital order the spin coupling is ferromagnetic, leading to the alignment of the spins within each of the distorted planes.  $\text{LaMnO}_3$  is still an antiferromagnet (AF): In the direction perpendicular to the planes, the spin coupling remains antiferromagnetic, as expected in the absence of alternating orbital order<sup>4</sup>.

**Methods and Materials:** The goal of the present study was to observe the AF resonance in zero external magnetic field. A well oriented single crystal of  $\text{LaMnO}_3$  has been prepared and characterized by X-ray and magnetic susceptibility measurements. The sample was disk-shaped, with a diameter of approximately 5mm and thickness of about 0.5mm. The AF transition was observed at  $T_N=140\text{K}$ , in accordance with the published values. The anisotropy of the magnetic susceptibility was clearly observed, indicating that the preferred direction of spin ordering is within the plane of the disk. The crystal was mounted on the cold finger of a He-flow cryostat, and the temperature dependence of the optical transmission was measured by using the recently installed SPS200 Fourier transform IR spectrometer. The spectral range of interest (below  $25\text{cm}^{-1}$ ) is in the very-far-infrared, and actually overlaps with the microwave range.

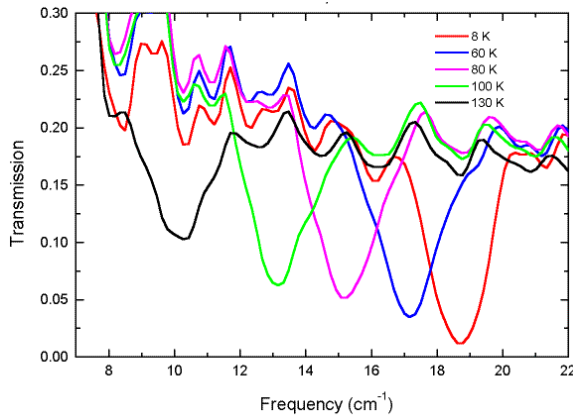


Figure 1. Antiferromagnetic resonance in  $\text{LaMnO}_3$

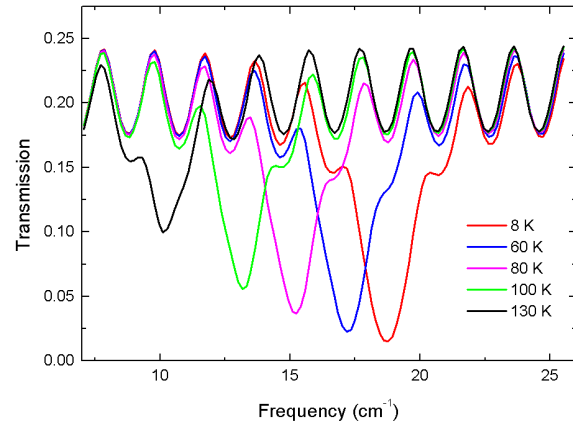


Figure 2. Simulations using the combination of simple electron spin resonance theory and optical transmission calculation.

**Results and Conclusions:** The AF resonance has been observed, and temperature dependence has been measured (Fig. 1). Simple electron spin resonance theory combined with the standard theory of EM wave propagation in dielectric medium and interfaces yields a good fit to the data (Fig. 2). The ESR spin susceptibility was found to be approximately independent of temperature  $T$ . The spin resonance frequency  $\omega_0$  decreased with increasing  $T$ . The low temperature value,  $\omega_0 = 18\text{cm}^{-1}$  is in agreement with the  $k=0$  spin wave frequency<sup>4</sup>. Contrary to expectations,  $\omega_0$  remained finite at the transition temperature ( $\omega_0 = 6\text{cm}^{-1}$  at  $T=T_N$ ).

**Acknowledgments:** This research has been supported by the NSF grant DMR 9803025. LM and DT acknowledge support by the NSLS.

**References:** <sup>1</sup> R. von Helmolt et al. Phys. Rev. Letters, **71**, 2331 (1993); <sup>2</sup> J.B. Goodenough et al. Phys. Rev. **124** 373 (1961); <sup>3</sup> J. Rodriguez-Carvajal et al. Phys. Rev. B **57** 3189 (1998); <sup>4</sup> F. Moussa et al. Phys. Rev. B **54** 15149 (1996)